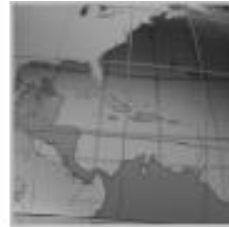


# White Paper



August 2016

## **3D Systems' ProJet MJP 2500 Series**

*Affordable, Easy-to-Use System Lowers Barriers to High-Precision 3D Printing*

## Table of Contents

Executive Summary.....	4
3D Printing Market Opportunity.....	4
About 3D Systems .....	4
Introduction – ProJet MJP 2500 Series .....	5
ProJet MJP 2500 – Key Features and Benefits.....	5
Key Specifications .....	5
MultiJet Printing and Phase Change Materials Enable High-Quality Parts .....	6
Rigid and Elastomeric Materials in Different Colors Allow for Various Uses .....	7
MJP EasyClean Post-Processing System Offers Ease-of-Use, Accuracy Benefits .....	8
Intuitive Workflow Tools Included with Device .....	8
Superior Print Speed on Full-Platform Prints.....	9
Office-Friendly, with No Ventilation or Special Connections Required .....	9
Professional Capabilities at an Affordable Price .....	9
ProJet MJP 2500 – Applications and Industries .....	10
Concept Modeling/Design Communication .....	10
Rapid Prototyping/Functional Prototyping .....	10
ProJet MJP 2500 – Differentiators.....	10
Ease of Use.....	10
Low Cost .....	11
MultiJet Printing Technology.....	11
ProJet MJP Product Portfolio .....	11
ProJet MJP 2500 – Customer Insights.....	13
Engtype – 3D Systems Partner and On-Demand Service Provider .....	13
Crescent Inc. – Virtual Reality and Motion Capture Company .....	13
InfoTrends' Opinion.....	14
Appendix.....	15
Authors.....	16

**List of Tables**

Table 1: ProJet MJP 2500 Series Specifications ..... 6

Table 2: 3D Systems MultiJet Plastic Printers Portfolio ..... 12

Table 3: ProJet MJP 2500 Series Materials and their Properties ..... 15

**List of Figures**

Figure 1: ProJet MJP 2500 Series Key Components..... 5

Figure 2: MultiJet Printing Technology Diagram ..... 7

Figure 3: Parts Made With ProJet MJP 2500 Materials..... 7

Figure 4: MJP EasyClean System ..... 8

Figure 5: 3DSPRINT Screen Shot..... 8

Figure 6: The ProJet MJP 2500’s Placement in an Office Environment ..... 9

Figure 7: The MultiJet Printing Phase Change Advantage ..... 11

Figure 8: Full Platform of Mass Printed by Engitype..... 13

Figure 9: Crescent Wearable Display Prototype Printed with ProJet 2500 ..... 14

## Executive Summary

In April 2016, 3D Systems began shipping a 3D printer that makes high-precision 3D printing more accessible to businesses. Starting under \$50,000, the ProJet MJP 2500 Series benefits from 3D Systems' MultiJet Printing technology, as well as its MJP EasyClean post-processing system. 3D Systems' MJP technology uniquely uses phase change material to deliver precise jetting and droplet control—ensuring that objects are produced as accurately as possible. The MJP EasyClean System streamlines the cleaning and finishing of parts. While these are some of the product's key attributes, it benefits from many other features. These include support for rigid and elastomeric materials; suitability for office environments; and overall ease of use spurred by simple setup, intuitive workflow software, and minimal intervention requirements.

## 3D Printing Market Opportunity

The ProJet MJP 2500 Series was launched amidst strong 3D printing forecasts. Currently valued at over \$5 billion,<sup>1</sup> the worldwide 3D printing market is expected to grow at an approximately 30% compound annual growth rate (CAGR) over the next several years.<sup>2</sup> This growth rate is particularly high when compared to other workflow and manufacturing products in the market, and reflects many of the benefits afforded by 3D printing in the product development sphere.<sup>3</sup> Furthermore, when considering the size of some of the industries offering the greatest opportunity for 3D printing (e.g., the \$9 trillion automotive industry and the \$700 billion aerospace and defense industry), it is clear this market has vast potential.

## About 3D Systems

Based in Rock Hill, South Carolina, 3D Systems is a leading provider of 3D products and services, including 3D printers, 3D print materials, 3D scanners, on-demand parts services, and digital design tools. With a 30-year history in 3D printing that originated with industrial stereolithography, the company is considered an industry pioneer. Today, 3D Systems offers a broad family of 3D printers that span a variety of technologies and needs.<sup>4</sup> When also considering the company's 3D software, scanning technologies, and production services, it is clear 3D Systems enables and supports customers at any level of 3D print adoption.

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<sup>1</sup> Based on market sizing from firms including Wohlers Associates and MarketsandMarkets.

<sup>2</sup> This figure is based on forecasting from firms including MarketandMarkets and International Data Corporation (IDC).

<sup>3</sup> Among other advantages, 3D printing enables companies to illustrate ideas quickly; develop better performing products; keep designs confidential and in-house; and save time and money around concept modeling, rapid prototyping, rapid tooling, and end-use manufacturing. Breakthroughs in 3D print technology, as well as more affordable printers, contribute to the high growth rates for this market.

<sup>4</sup> Printers are available for virtually every environment, and address applications ranging from design communication to end-use manufacturing.

## Introduction – ProJet MJP 2500 Series

In April 2016, 3D Systems launched its latest ProJet MultiJet printer: the MJP 2500/MJP 2500 Plus. Starting under \$50,000, the device is considered an entry-level professional printer, employing 3D Systems' MultiJet Printing technology. This white paper will explore the device's key attributes, benefits, applications, and differentiators. It will also provide an overview of the product in the context of the larger ProJet MultiJet Printing portfolio, insights from current customers, as well as InfoTrends' opinion of the technology's value and potential.

**Figure 1: ProJet MJP 2500 Series Key Components**



- A. **Print engine:** The print engine contains major systems, such as the printhead, planarizer, and UV lamp assembly.
- B. **Build chamber:** The build chamber is the area where the print platform can be found. All print jobs are built on the print platform.
- C. **User interface (UI):** This is the built-in touchscreen that allows the user to interface with the printer. The touchscreen allows the user to check printing status and material levels, as well as power the printer off.
- D. **Power cord and power switch:** The electrical power cord is plugged into the printer here. There is also a power switch located next to the power outlet.
- E. **Material deliver module (MDM):** The MDM drawer is a push/push type mechanism. To open the drawer, push in. The drawer should pop open, allowing the user to pull it open the rest of the way. The MDM contains the part and support materials, as well as the waste bag.

## ProJet MJP 2500 – Key Features and Benefits

### Key Specifications

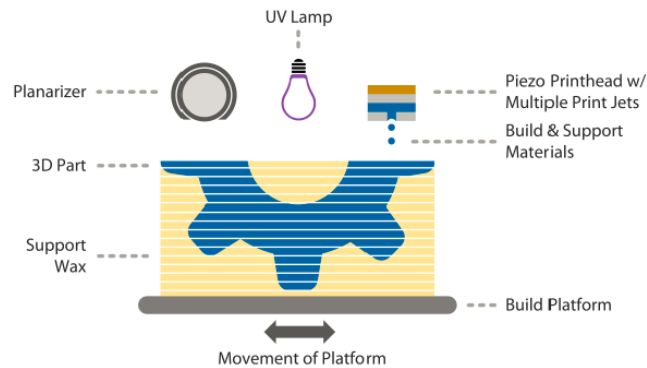
The following table shows some key specifications of the ProJet MJP 2500/2500 Plus 3D printer, including its net build volume, network connectivity, and optional five-year printhead warranty. The main difference between the base and Plus model is support for three additional materials in the Plus version.

**Table 1: ProJet MJP 2500 Series Specifications**

	<b>ProJet MJP 2500</b>	<b>ProJet MJP 2500 Plus</b>
<b>Technology</b>	MultiJet Printing technology	
<b>Net Build Volume (xyz)</b>	11.6 x 8.3 x 5.6 in (295 x 211 x 142 mm)	
<b>Resolution (xyz)</b>	800 x 900 x 790 DPI, 32 $\mu$ layers	
<b>Accuracy (typical)</b>	$\pm 0.004$ in per in ( $\pm 0.1016$ mm per 25.4 mm) of part dimension. Accuracy may vary depending on build parameters, part geometry and size, part orientation, and post-processing.	
<b>Print Speed in Z</b>	1 lane: 0.26 in/hr (6.6 mm/hr); 2 lane: 0.19 in/hr (4.8 mm/hr); 3 lanes 0.12 in/hr (3mm/hr)	
<b>Build Materials</b>	VisiJet M2 RWT – Rigid White VisiJet M2 RBK – Rigid Black	VisiJet M2 RWT – Rigid White VisiJet M2 RBK – Rigid Black VisiJet M2 RCL – Rigid Clear VisiJet M2 EBK – Elastomeric Black VisiJet M2 ENT – Elastomeric Natural
<b>Included Software</b>	3DSPRINT software	
<b>Internal Hard Drive Capacity</b>	500 Gb minimum	
<b>Connectivity</b>	Network ready with 10/100/1000 BaseT Ethernet interface USB port	
<b>Data Files Supported</b>	STL, CTL, OBJ, PLY, ZPR, ZBD, AMF, WRL, 3DS, FBX	
<b>Post Processing</b>	MJP EasyClean System for easy removal of wax supports	
<b>Five-Year Printhead Warranty</b>	Optional	

### **MultiJet Printing and Phase Change Materials Enable High-Quality Parts**

The ProJet MJP 2500 Series employs 3D Systems' MultiJet Printing technology. This technology is anchored around two key components: 1) a piezoelectric printhead, capable of precise jetting of UV-curable liquid, and 2) phase change support material. The phase change support material is a paraffin-based wax. During the printing process, liquid part and support material are heated, fed through the high-resolution printhead, and jetted as droplets. These droplets are deposited onto the build surface, which is based on the object design. The liquid support material starts solidifying after being jetted, preventing the liquid part material from expanding upon contact with the build surface. Once the part material is on the build surface, it is cured using UV light to form the final object. This powerful combination results in 3D-printed parts with enhanced edge definition, final part performance, and accuracy.

**Figure 2: MultiJet Printing Technology Diagram**

Other 3D printing technologies have the challenge of attempting to jet and cure simultaneously in order to maintain droplet control, since droplets will flow freely until they are UV cured. This can compromise edge definition, sidewall quality, and feature definition, as it is physically impossible to jet and cure completely at the same time. MultiJet Printing technology uniquely leverages phase change materials and piezoelectric printheads to accurately reproduce true-to-CAD models and deliver overall superior part quality.

### Rigid and Elastomeric Materials in Different Colors Allow for Various Uses

All of the materials supported by the ProJet MJP 2500 Series are liquid photopolymer resins. Some are rigid when cured, while others are flexible or “elastomeric” following curing. The ProJet MJP 2500 supports two rigid materials (white and black), while the ProJet MJP 2500 Plus supports three rigid materials (white, black, and clear) and two elastomeric materials (black and natural). The rigid materials allow for rigorous testing and use, making them a good choice for applications requiring a durable plastic. The elastomeric materials are ideal for printing rubber-like parts, like gaskets and piping, which require pliability and strength.

**Figure 3: Parts Made With ProJet MJP 2500 Materials**

Material selection is generally driven by customer requirements, with consideration given to the mechanical properties needed for the application. VisiJet M2 RBK (Rigid Black), for example, has a good mix of moderate tensile strength (29-37 Mpa) and elongation (11-21%)—making it a tough material suitable for some rigorous prototype testing. VisiJet M2

Rigid Clear (RCL), by contrast, is an exceptionally stiff plastic (tensile strength of 40-50 Mpa), which makes it ideal for panels, housings, and other parts requiring rigidity and strength. Users can easily switch between different materials by using a material changeover (MCO) wizard, via the printer interface. MCO Cleaner 2500 aids in the complete flushing of the system during material changeover, minimizing the use of part material during the process.

### **MJP EasyClean Post-Processing System Offers Ease-of-Use, Accuracy Benefits**

The ProJet MJP 2500 printer also launched with the new MJP EasyClean System, an automated post-processing system that removes wax support from parts in under 30 minutes. The gentle method of using steam and soy-based oil to melt away wax supports differs from other processes that use manual removal and/or high-pressure techniques that may damage parts. The MJP EasyClean solution adds to the overall object fidelity and quality beyond the spatial resolution specification of the system, which sets this product line apart from competitive devices.

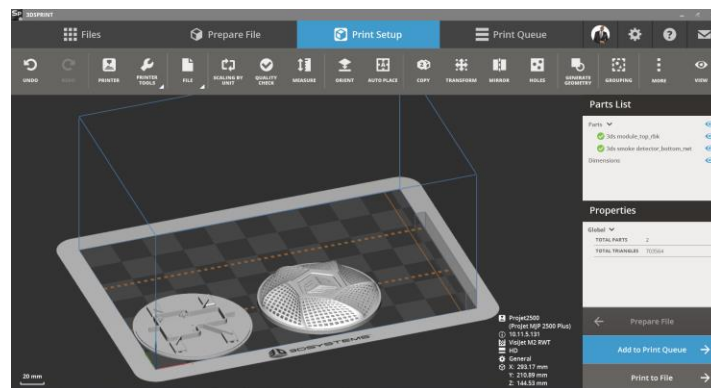
**Figure 4: MJP EasyClean System**



### **Intuitive Workflow Tools Included with Device**

Both versions of the ProJet MJP 2500 come with 3D Systems' 3DSPRINT software for easy job submission, control, and monitoring. The software can analyze part files to determine their suitability for the MJP 2500 printer. Other components include file repair, build time estimation, optimal part positioning, and print queue management.

**Figure 5: 3DSPRINT Screen Shot**





The MJP 2500 also has a touchscreen, from which users can perform a variety of functions to control the printer. These include starting a print job, running diagnostic procedures, and changing material.

### **Superior Print Speed on Full-Platform Prints**

The ProJet MJP 2500 Series has a “Z” print speed of 0.26 inches an hour (6.6 millimeters an hour) for one lane, 0.19 inches an hour (4.8 millimeters an hour) for two lanes, and 0.12 inches an hour (three millimeters an hour) for three lanes. While the nearest competition beats out the ProJet MJP 2500 on one-lane builds (small or narrow geometries), the printer exhibits the greatest speed advantage when parts cover the entire build platform. Other benefits around speed include quick and seamless installation from crate to printing (two to three hours), quick job setup and submission using 3DPRINT software, and hands-free post-processing in less than 30 minutes (which is up to four times faster than other methods requiring human handling of parts) with the MJP EasyClean System.

### **Office-Friendly, with No Ventilation or Special Connections Required**

The ProJet MJP 2500 is well suited for office and small lab environments, with no special ventilation required. The device takes up little space, uses standard power and networking, and produces no chemicals. It can also be used by a variety of workplace employees, since it has low requirements for setup, operation, and maintenance. Users can receive an alert when material is low, allowing them to pause the job to add a new bottle of material. Other tasks are only required on a monthly or every-few-months basis (e.g., inspecting the planarizer blade and housing, cleaning, and inspecting the carbon filter).

**Figure 6: The ProJet MJP 2500's Placement in an Office Environment**



### **Professional Capabilities at an Affordable Price**

With the introduction of the ProJet MJP 2500, 3D Systems has brought the benefits of its MultiJet Printing technology to a wider pool of businesses and organizations. Starting under \$50,000, the device is the lowest-priced product employing this technology. At the same time, the product offers advantages around running costs. For example, unlike competitive technology, the support material does not require a portion of more

expensive part material. Not needing plumbing inlets or outlets can save thousands of additional dollars, while cost savings are also achieved through long-lasting print heads.

## **ProJet MJP 2500 – Applications and Industries**

### **Concept Modeling/Design Communication**

The ProJet MJP 2500 is well suited for the first stage of product creation: concept modeling. In this stage, an object is manufactured to communicate design intent, as opposed to for testing, tool creation, or end use. For example, automobile engineers may print a model of a car with a new form factor as part of a discussion with management on the company's future initiatives. This application is more about design accuracy and iteration and less about product functionality. These types of objects may also be used for sales and marketing purposes to communicate current or upcoming projects.

### **Rapid Prototyping/Functional Prototyping**

Going beyond the concept modeling stage, the ProJet MJP 2500 Series also can be used for functional prototyping—as a way to validate designs. Prototypes can be created for a variety of testing areas, including assemblies, form and fit testing, mechanical functional testing, durability and harsh environment testing, and fluid flow analysis. Testing can span many industries and product categories, including electronics, home appliances, automobile accessories, automobile components, robotics, and energy equipment. In addition to design and production environments, this type of testing can be useful within educational settings.

## **ProJet MJP 2500 – Differentiators**

### **Ease of Use**

Compared to other 3D print technology requiring significant technical expertise, the ProJet MJP 2500 Series was designed with ease of use in mind. Everything, from setup to printing to post-processing to user maintenance, can be performed by non-technical teams.<sup>5</sup> The plug-and-play device can be up and running in two to three hours, and requires no daily or weekly tasks, beyond changing the platform to start a new job or loading new material cartridges.<sup>6</sup> Other ease-of-use benefits include automatic email alerts when material is low, simple material replacement using the Material Changeover wizard, and the hands-free MJP EasyClean post-processing system.

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<sup>5</sup> In instances when a significant technical problem does arise with the machine, a 3D Systems channel partner is able to deploy a technician to the customer site.

<sup>6</sup> Competitive devices require daily or weekly tasks like cleaning the print heads, performing patterning tests, cleaning and inspecting the wiper, and clearing the build tray and surrounding area.

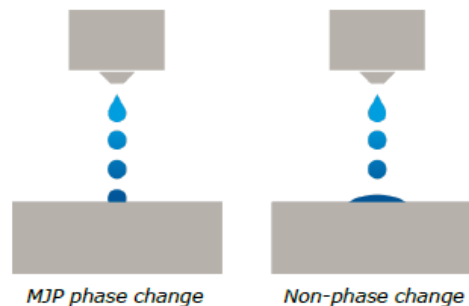
### Low Cost

Another key differentiator is the product's low cost. Most 3D printers for professional environments fall within the \$50,000 - \$100,000 range, while the ProJet MJP 2500 Series starts under \$50,000. Despite the low cost, the printer offers all the benefits of MultiJet Printing technology—including high precision, support for concept modeling and functional prototyping applications, and compatibility with rigid and elastomeric materials in various colors. Further cost savings are achieved through no part material needed for the support material,<sup>7</sup> no plumbing required for post-processing, and long-lasting printheads.

### MultiJet Printing Technology

The product's MultiJet Printing technology is another distinguishing attribute. When phase change part and/or support material lands on the build platform, it cools and stays in place immediately—enabling CAD model features to be accurately reproduced. While customers may view resolution and layer thickness as the key measurements of part accuracy, the truth is they do not account for deviations between the CAD file and the object produced. When these items are inconsistent, it can make the difference between a properly or improperly functioning part. For instance, a shower head with altered spray holes may produce erratic water streams.

**Figure 7: The MultiJet Printing Phase Change Advantage**



### ProJet MJP Product Portfolio

The ProJet MJP 2500 and 2500 Plus are two of five printers in 3D Systems' MultiJet Printing portfolio. For plastic and elastomeric parts, the higher-end ProJet MJP 3600, ProJet MJP 3600 Max, and ProJet MJP 5500X integrate more advanced features—such as larger maximum build volumes, higher resolutions, a greater selection of build materials (e.g., the top-of-the line MJP 5500X supports more than 100 composite combinations), suitable finishers, and a standard five-year printhead warranty. This collection of printers covers all stages of product development (including end-use manufacturing), and boasts features like medical certification capability, castability, high

<sup>7</sup> Part material is more expensive.

temperature resistance, and the ability to print parts with multiple materials and special features (like overmolding).

**Table 2: 3D Systems MultiJet Plastic Printers Portfolio**

	ProJet MJP 2500	ProJet MJP 2500 Plus	ProJet MJP 3600	ProJet MJP 3600 Max	ProJet MJP 5500X
<b>Maximum Build Envelope Capacity (xyz)</b>	11.6 x 8.3 x 5.6 in (295 x 211 x 142 mm)		HD mode: 11.75 x 7.2 x 8 in (298 x 183 x 203 mm) UHD & XHD modes: 8 x 7 x 8 in (203 x 178 x 203 mm)	All modes: 11.75 x 7.2 x 8 in (298 x 183 x 203 mm)	All modes: 20.4 x 15 x 11.8 in (518 x 381 x 300 mm)
<b>Resolution (xyz)</b>	800 x 900 x 790 DPI, 32 μ layers		HD mode: 375 x 450 x 790 DPI, 32 μ layers; UHD mode: 750 x 750 x 890 DPI, 29 μ layers; XHD mode: 750 x 750 x 1600 DPI, 16 μ layers		HD mode: 375 x 375 x 1000 DPI, 25 μ layers; UHD & UHDS modes: 600 x 600 x 1600 DPI, 16 μ layers; XHD & XHDS modes: 750 x 750 x 2000 DPI, 13 μ layers
<b>Typical Accuracy</b>	±0.004 in per in (±0.1016 mm per 25.4 mm) of part dimension		±0.001-0.002 in per in (±0.025-0.05 mm per 25.4 mm) of part dimension		
<b>Build Materials</b>	VisiJet M2 RWT – Rigid White VisiJet M2 RBK – Rigid Black	VisiJet M2 RWT – Rigid White VisiJet M2 RCL – Rigid Clear VisiJet M2 RBK – Rigid Black VisiJet M2 EBK – Elastomeric Black VisiJet M2 ENT – Elastomeric Natural	VisiJet M3-X – Rigid White VisiJet M3 Crystal – Rigid Clear VisiJet M3 Black – Rigid Black VisiJet M3 Proplast – Rigid Natural VisiJet M3 Navy – Rigid Blue VisiJet M3 Techplast – Rigid Gray VisiJet M3 Procast - Castable		Base materials: VisiJet CR-WT – Rigid White VisiJet CR-CL – Rigid Clear VisiJet CE-BK – Elastomeric Black VisiJet CE-NT – Elastomeric Natural  <i>Plus more than 100 composite combinations</i>
<b>VisiJet Support Material</b>	Eco-friendly, easily removable wax				
<b>Post Processing</b>	MJP EasyClean System		ProJet Finisher		ProJet Finisher XL
<b>Included Software</b>	3DSPRINT		ProJet Accelerator		3DSPRINT
<b>Standard Warranty</b>	One year parts and labor		One year parts and labor Five-year printhead		

The products have applications in virtually every industry, including automotive, aerospace and defense, electronics, energy, jewelry/watches, packaging, medical, sports equipment and toys, and toolmaking.

## ProJet MJP 2500 – Customer Insights

Customers like U.S.-based Engitype and Japan-based Crescent Inc. are benefiting from the ProJet MJP 2500 Series. Headquartered in Seattle, Washington, Engitype is a 3D Systems partner that also provides on-demand 3D printing services. Crescent Inc., meanwhile, is a virtual reality, motion capture, and interactive content creation company based in Tokyo, Japan.

### Engitype – 3D Systems Partner and On-Demand Service Provider

As of May 2016, Engitype had used the ProJet MJP 2500 to build 67 objects. None of the jobs failed, according to CEO and Owner John Savage. He said this occurred despite trying to get the printer to fail. “We would arrange it so that a build would run out of material mid-process or we would arrange it so that the waste system would overflow,” he said. “We’d set up different circumstances trying to see how the printer would respond. And in every single circumstance the printer itself would either pause or put itself into a hold state and wait for the issue to be resolved and then continue building.” Savage also highlighted the device’s new printhead design, its ability to drive full platforms of mass, its fast warmup time (six minutes from standby mode, and 30 minutes from a cold state), and its user-friendly maintenance features.<sup>8</sup>

**Figure 8: Full Platform of Mass Printed by Engitype**



### Crescent Inc. – Virtual Reality and Motion Capture Company

Crescent Inc. is using the ProJet MJP 2500 to produce prototypes of its new head-mounted wearable displays for virtual reality gaming. Previous prototypes had to be finished by hand, and were not sufficiently accurate. Crescent turned to the ProJet MJP 2500 because of its part quality, fine detail, and resolution—all of which meet its form and fit functional requirements.

Printed in multiple parts and then assembled together, the new prototypes weigh 33% less than their predecessors—providing a more comfortable experience for the customer. Crescent is currently developing its next generation of head-mounted displays, which will

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<sup>8</sup> For example, the majority of calibration is done automatically, and printhead cleaning cycles take just 60 seconds.

include improvements like Wi-Fi capability. As the displays are ideally customized for each customer, Crescent considers the ProJet MJP 2500 to be the perfect tool for the project.

**Figure 9: Crescent Wearable Display Prototype Printed with ProJet 2500**



### InfoTrends' Opinion

InfoTrends believes that 3D Systems' new ProJet MJP 2500 Series lowers the barriers to high-precision 3D printing, with its relative affordability, ease of use, and parts accuracy capability (achieved through MultiJet Printing technology). When paired with the overall benefits afforded by 3D printing technology, including greater design flexibility, shorter product development cycles, and a reduction in costs, it is evident the ProJet MJP 2500 Series has much to offer design and manufacturing entities.

Within its class of products, the ProJet MJP 2500 Series is particularly distinguished by the precision of its parts, as well as the productivity achieved through fast multi-lane printing. These characteristics make it ideal for applications like functional prototyping—where accuracy is essential in adequately testing parts or products. The rigid and flexible material options further support its appropriateness for this stage of product development, enabling different material toughness, elongation, transparency, water tightness, and other attributes within 3D-printed objects.

InfoTrends believes industries like automotive, aerospace and defense, energy, and consumer goods would benefit most from the ProJet MJP 2500 Series—given the constant product design innovation occurring in these sectors, as well as the need for precise, thoroughly tested parts. Conversely, the sheer size of these industries (e.g., the \$9 trillion automotive industry and the \$700 billion aerospace and defense industry) makes them attractive targets for 3D Systems as it seeks to take 3D printing to the next level. While the 3D printing market is currently valued around \$5 billion, it has the potential to achieve exponential growth in the years ahead—fueled by high-quality, affordable products like the ProJet MJP 2500.

This material is prepared specifically for clients of InfoTrends, Inc. The opinions expressed represent our interpretation and analysis of information generally available to the public or released by responsible individuals in the subject companies. We believe that the sources of information on which our material is based are reliable and we have applied our best professional judgment to the data obtained.

## Appendix

**Table 3: ProJet MJP 2500 Series Materials and their Properties**

Properties	VisiJet M2 RWT	VisiJet M2 RBK	VisiJet M2 RCL	VisiJet M2 ENT	VisiJet M2 EBK	VisiJet M2 Sup
<b>Composition</b>	UV Curable Plastic			UV Curable Elastomeric Material		Wax Support Material
<b>Color</b>	Opaque White	Opaque Black	Translucent Clear	Translucent Natural	Opaque Black	White
<b>Bottle Quantity</b>	1.5 kg					1.4 kg
<b>Density @ 20 °C (solid)</b>	1.19 g/cm <sup>3</sup>		1.18 g/cm <sup>3</sup>	1.12 g/cm <sup>3</sup>		N/A
<b>Tensile Strength</b>	37-47 MPa	29-37 MPa	40-50 MPa	0.2-0.4 MPa 0.2-0.4 MP		N/A
<b>Tensile Modulus</b>	1000-1600 MPa	600-1100 MPa	1000-1600 MPa	0.27-0.43 MPa		N/A
<b>Elongation at Break</b>	7-16 %	11-21 %	11-21 %	160-230 %		N/A
<b>Flexural Strength</b>	59-69 MPa	44-60 MPa	73-83 MPa	N/A	N/A	N/A
<b>Flexural Modulus</b>	1400-2000 MPa	900-1500 MPa	1700-2300 MPa	N/A	N/A	N/A
<b>Impact Strength (Notched Izod)</b>	29 J/m	26 J/m	26 J/m	N/A	N/A	N/A
<b>Shore A Hardness</b>	N/A	N/A	N/A	28-32	28-32	N/A
<b>Shore D Hardness</b>	77-80	77-80	77-80	N/A	N/A	N/A
<b>Water Absorption</b>	0.5%	0.5%	0.5%	0.9%	0.6%	N/A
<b>Heat Distortion Temperature @ 0.45 MPa</b>	52 °C	48 °C	54 °C	N/A	N/A	N/A
<b>Heat Distortion Temperature @ 1.82 MP</b>	46 °C	43 °C	47 °C	N/A	N/A	N/A
<b>Melting Point</b>	N/A	N/A	N/A	N/A	N/A	60 °C
<b>Softening Point</b>	N/A	N/A	N/A	N/A	N/A	40 °C
<b>Printer Compatibility</b>	ProJet MJP 2500 ProJet MJP 2500 Plus	ProJet MJP 2500 ProJet MJP 2500 Plus	ProJet MJP 2500 ProJet MJP 2500 Plus	ProJet MJP 2500 Plus	ProJet MJP 2500 Plus	ProJet MJP 2500 ProJet MJP 2500 Plus
<b>Description</b>	Rigid White	Rigid Black	Rigid Natural	Flexible Rubber-like	Flexible Rubber-like	Non-toxic wax material for hands-free melt-away supports

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